

# Interchangeability Testing in San Diego with Imported LNG

California Energy and Air Quality  
Conference

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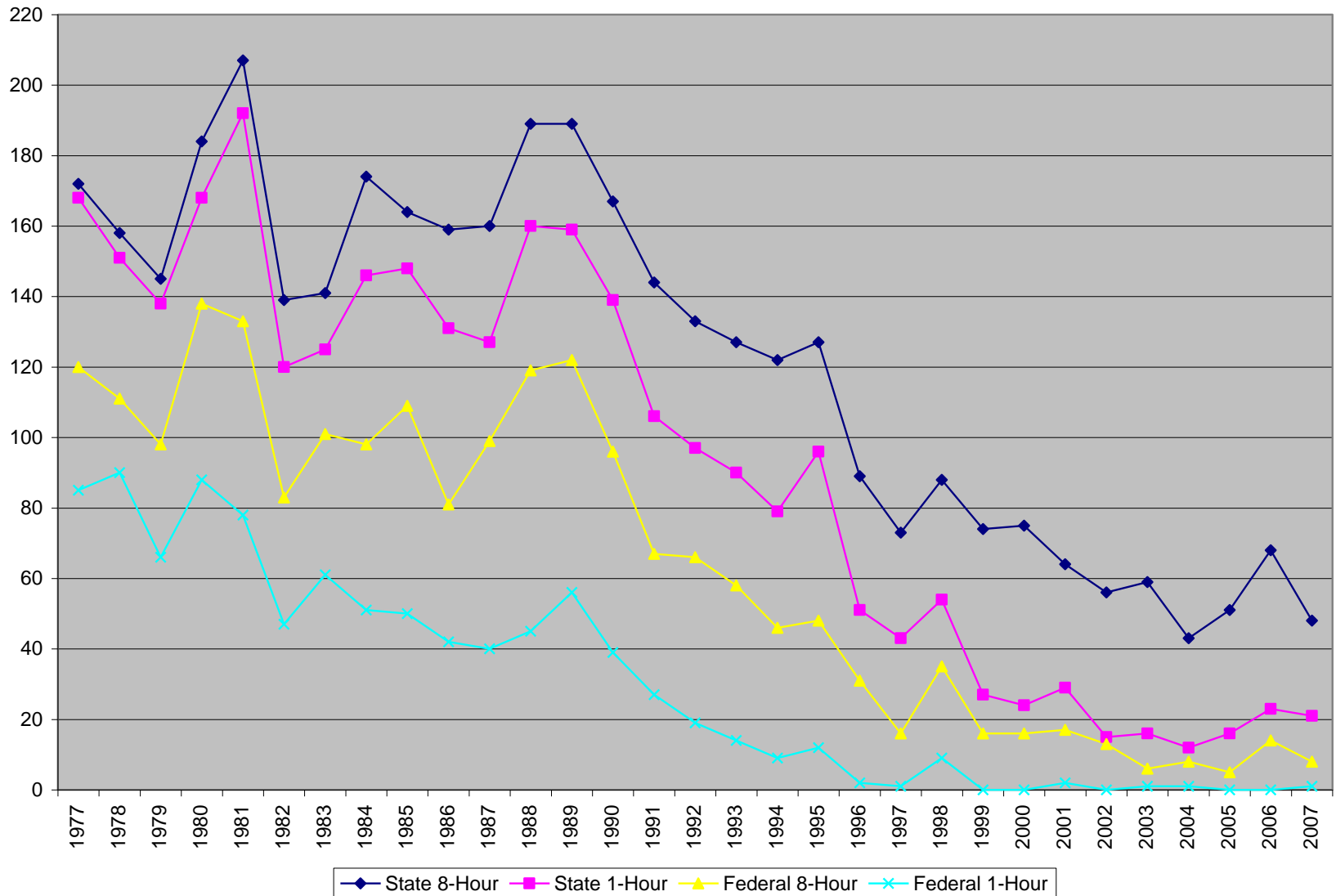
# Introduction



# San Diego Attainment Status

Pollutant	Federal	State
Carbon Monoxide	Attainment	Attainment
Nitrogen Dioxide	Attainment	Attainment
Sulfur Dioxide	Attainment	Attainment
Lead	Attainment	Attainment
Particulate Matter	Attainment	Non-Attainment
Ozone	Non-Attainment	Non-Attainment

# Days Exceeding Air Quality Standards for Ozone



# Liquefied Natural Gas (LNG) vs Historical Natural Gas

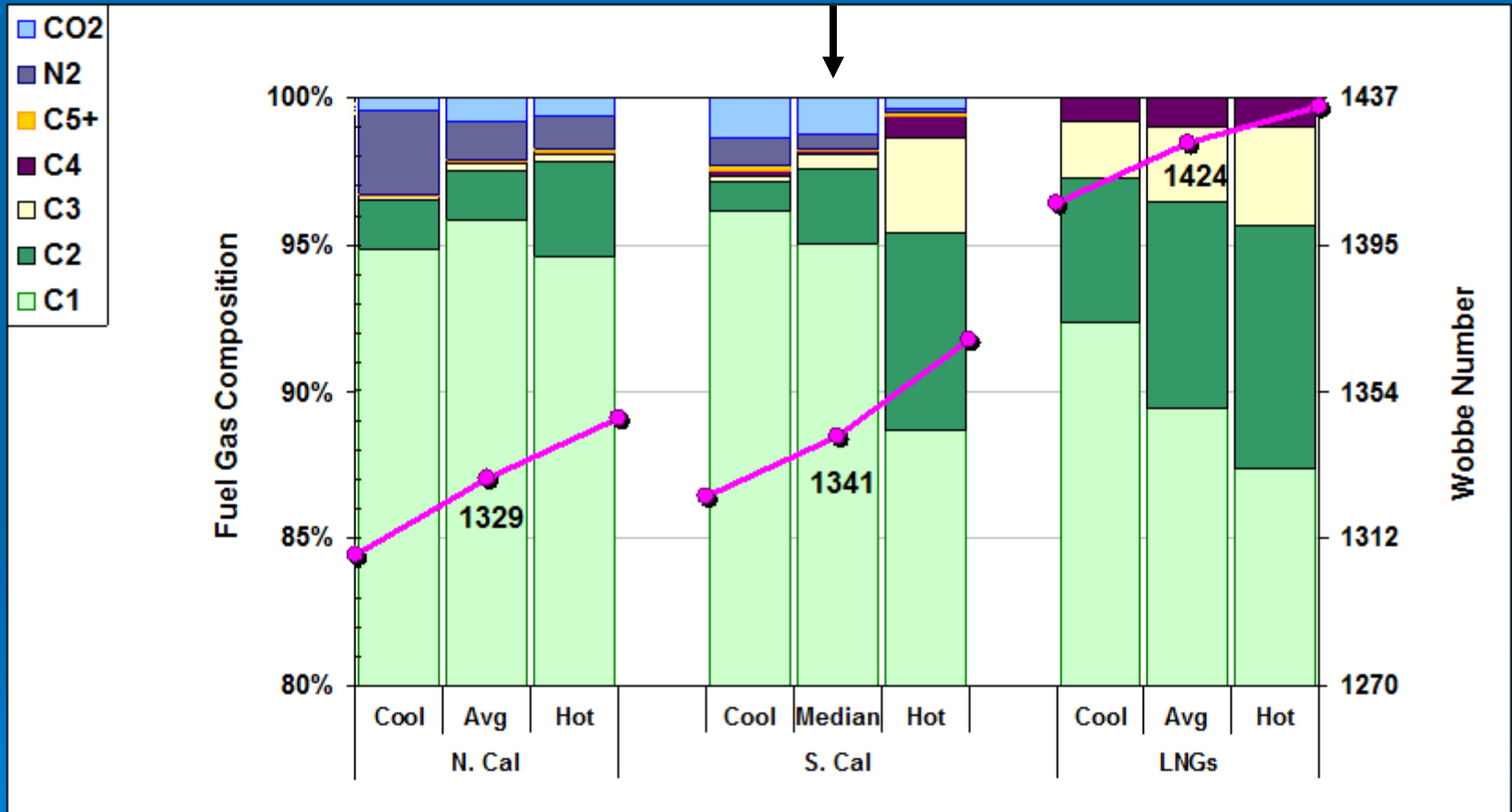
- *San Diego natural gas composition has been very stable over many years*
- *Natural gas derived by revaporizing LNG has a significantly different gas composition from historic pipeline (base) natural gas*

# Emission Impact Concerns

- *Combustion equipment can be tuned to operate well over a wide range of gas compositions*
- *Some equipment has shown significant emission increases when operating on LNG after being tuned on historic pipeline natural gas*
- *Limited information available on potential emission impacts*

# LNG vs. CA Historic Natural Gas

San Diego

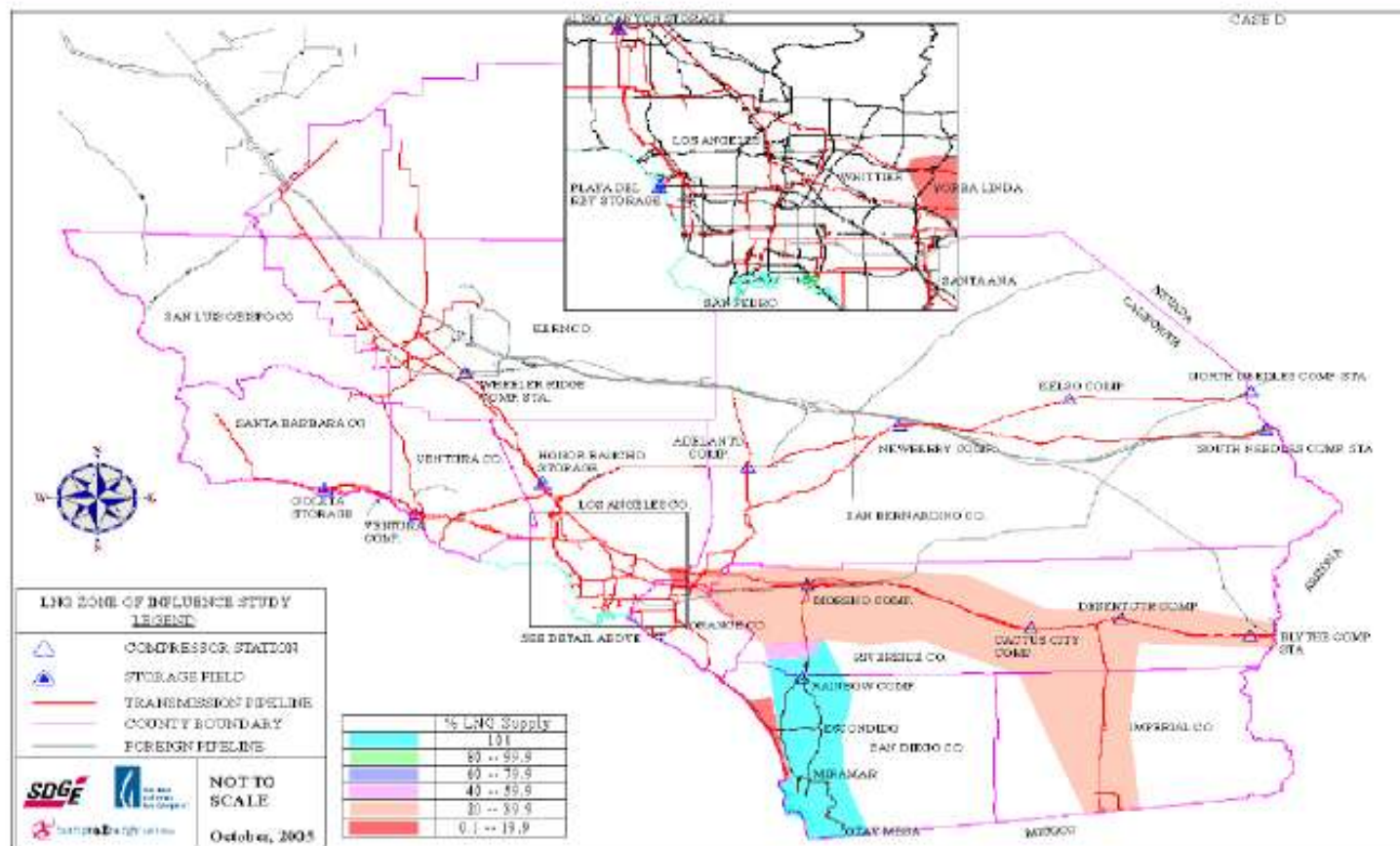


# LNG Event

- *“LNG Event” commissioning of Sempra’s Energia Costa Azul (ECA) liquefied natural gas (LNG) terminal in Baja, California*
- *Large influx of LNG-derived natural gas on May 9, 2008, into San Diego*
- *Future LNG use in San Diego may be extensive (2009?)*

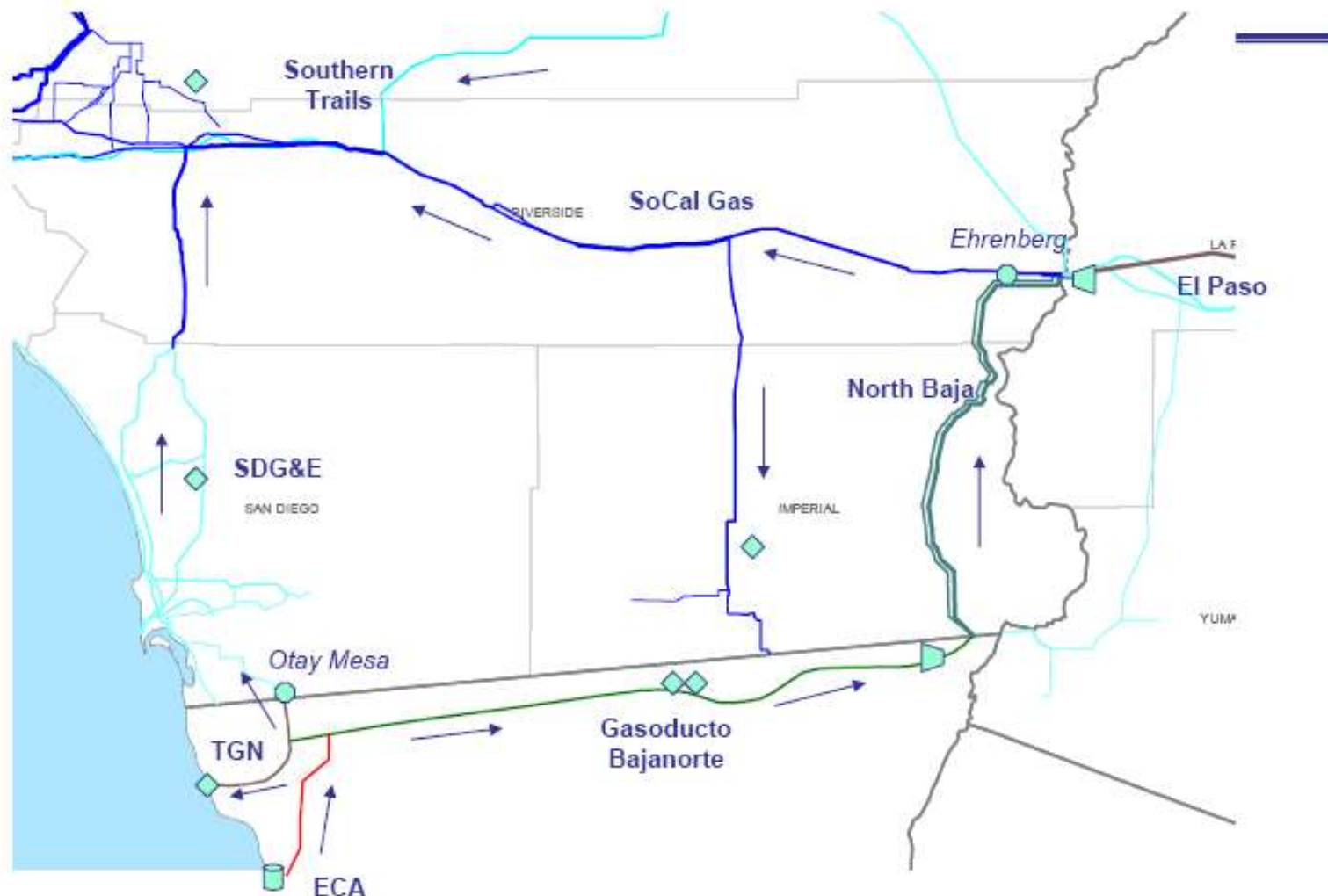


# Costa Azul Zone of Influence for Rollout Planning





# Energia Costa Azul & Pipelines to California



ECA Terminal Start Up Presentation,  
Semptra LNG

# Testing During LNG Event

- *District source tests of permitted equipment*
- *SoCal Gas and SDG&E Tests*
  - Separate from, but coordinated with, District testing
- *Collection of CEMS data*

# Background



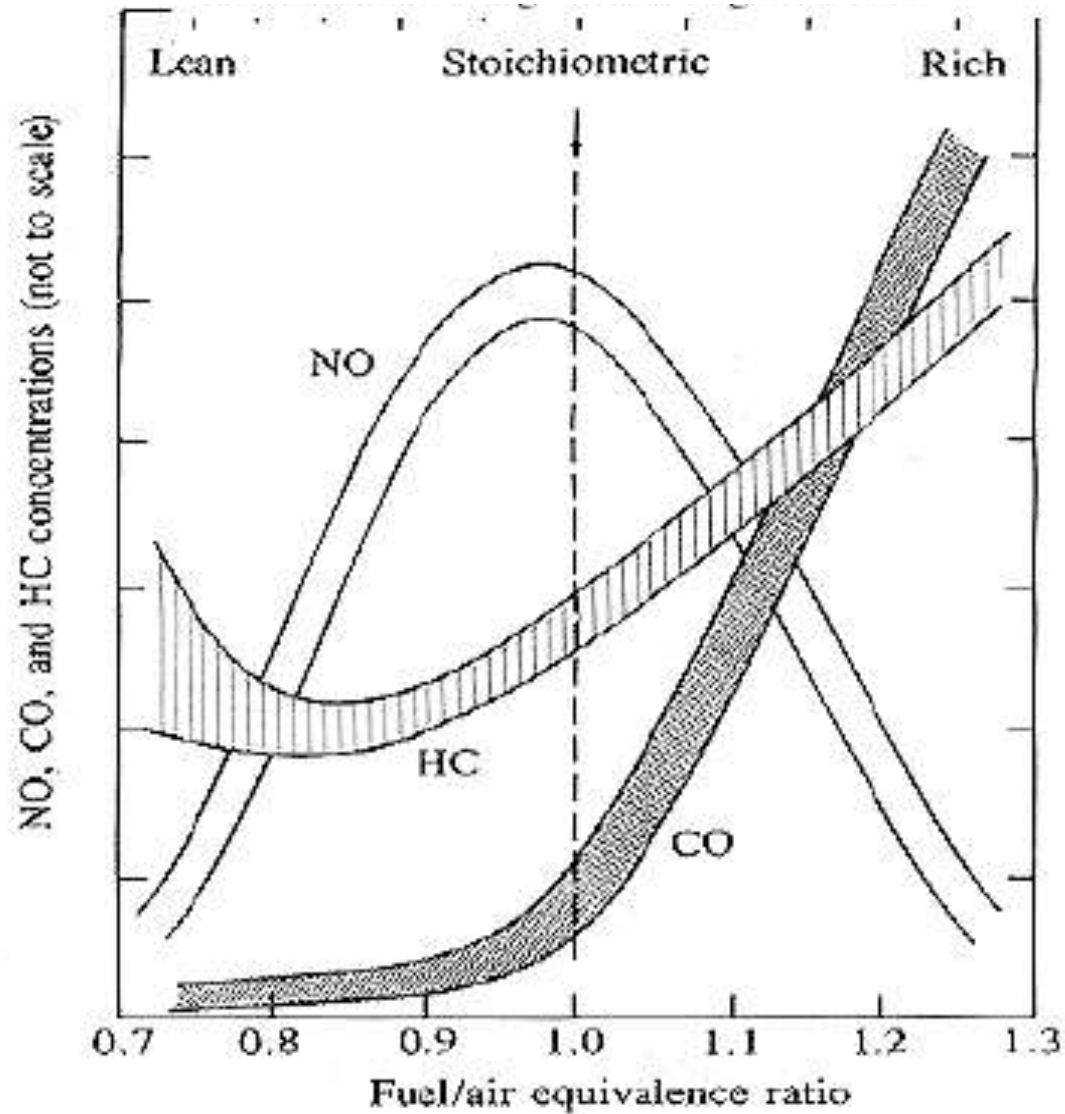
# Wobbe Index

- *Common measure of effect of natural gas composition on combustion equipment*
- *$WI = HHV / (\text{specific gravity})^{0.5}$*
- *HHV and specific gravity at STP*
- *Measure of fuel heat input to a combustor through an opening with a fixed size (constant fuel T & P)*

# Wobbe Index and Emissions

- *For natural gas fuels metered through a fixed opening and with a fixed air supply, **fuel to air ratio is directly proportional to the Wobbe Index***
- *Once tuned, changes in fuel to air ratio can strongly effect emissions*
- *Wobbe Index for most LNG is higher (1385 is PUC limit) than for historic San Diego pipeline gas (about 1335)*

Increasing Wobbe →



Source: Gas Technology Institute

# Wobbe Index and Emissions

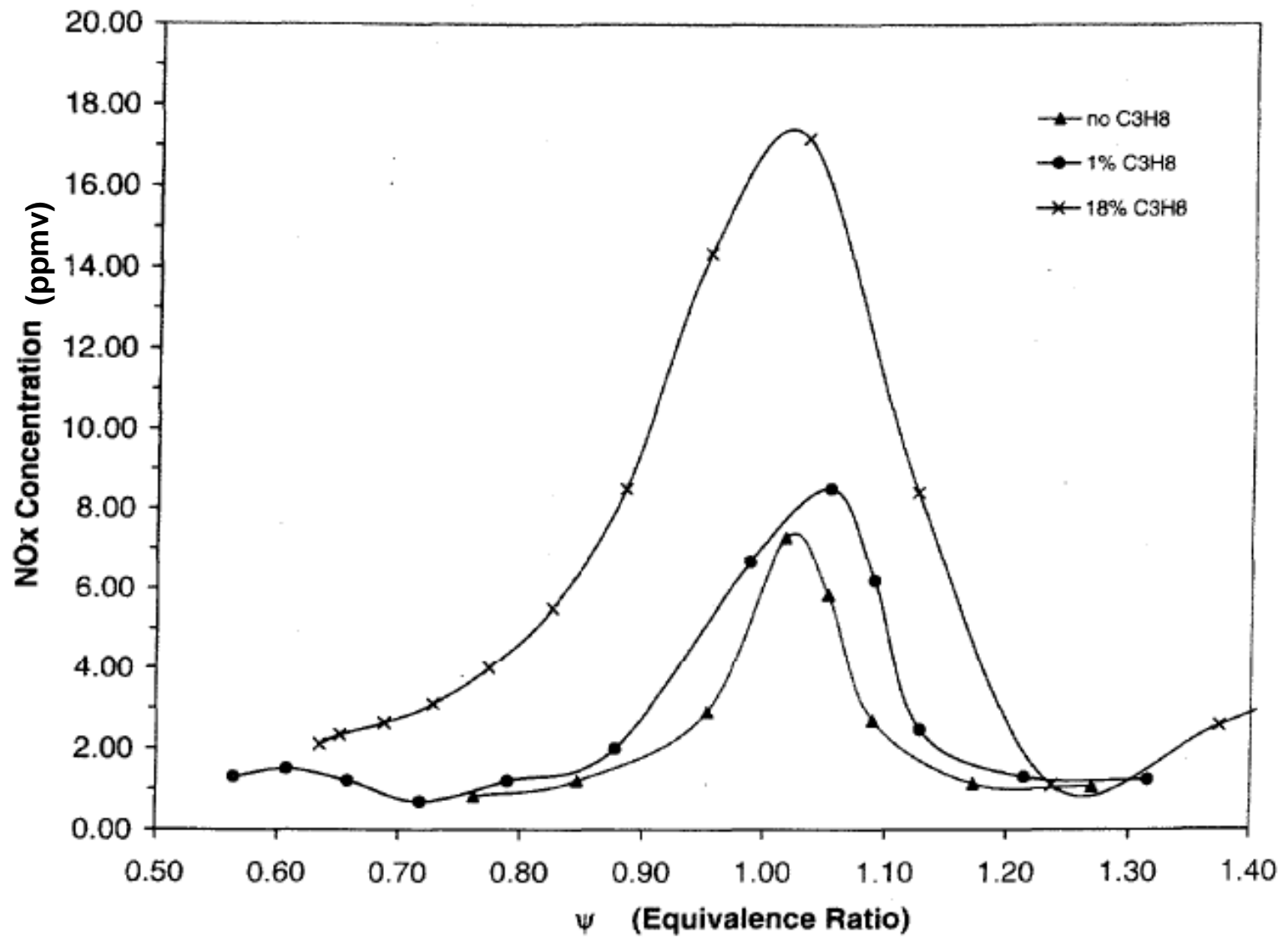
- *Most commercial and residential equipment can not easily or routinely adjust fuel or air flow*
- *Lean premix devices are especially sensitive*
- *Devices with diffusion flames less so*

# Industrial Equipment

- *Operational controls that may compensate for changes in Wobbe Index are common but not universal*
  - Fuel adjustment for load following
  - Air adjustment with O<sub>2</sub> trim systems
- *Mitigates emission changes?*

# Beyond the Wobbe Index

- *Ethane and propane have higher adiabatic flame temperatures than methane at the same fuel to air ratio*
- *Ethane and propane have higher flame speeds than methane at the same fuel to air ratio*
- *Combustion chemistry details*



# Testing



# District Test Program



# Objectives

- *Provide information to help assess potential emission impacts from LNG*
- *Provide information to help assess potential compliance issues from LNG*
- *Identify any operational problems from LNG*

# Equipment Selection

- *Issued advisory that District would not take action on any exceedance during testing*
- *Requested voluntary participation*
- *Goal was to include sensitive equipment (lean premix combustors, little operational controls)*
- *Not entirely successful (e.g., boilers)*

# Additional LNG Emission Impact Information

- *District requested and received CEMS data for several pieces of equipment*
- *Most with add-on air pollution controls*

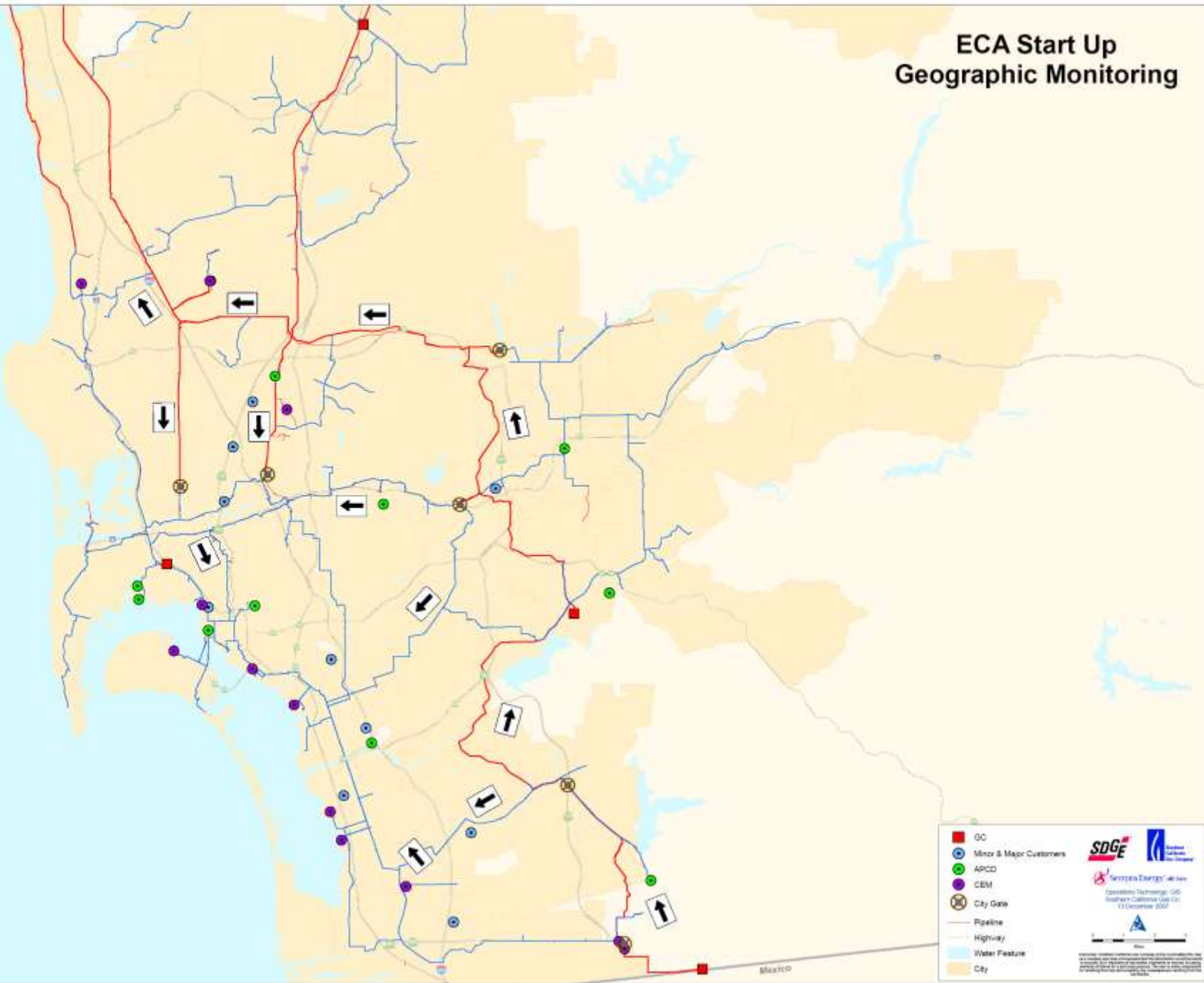
# SoCal Gas/SDG&E Test Program

- *Closely coordinated with District and asked for District input (several meetings and conference calls)*
- *Actual testing not witnessed by District*

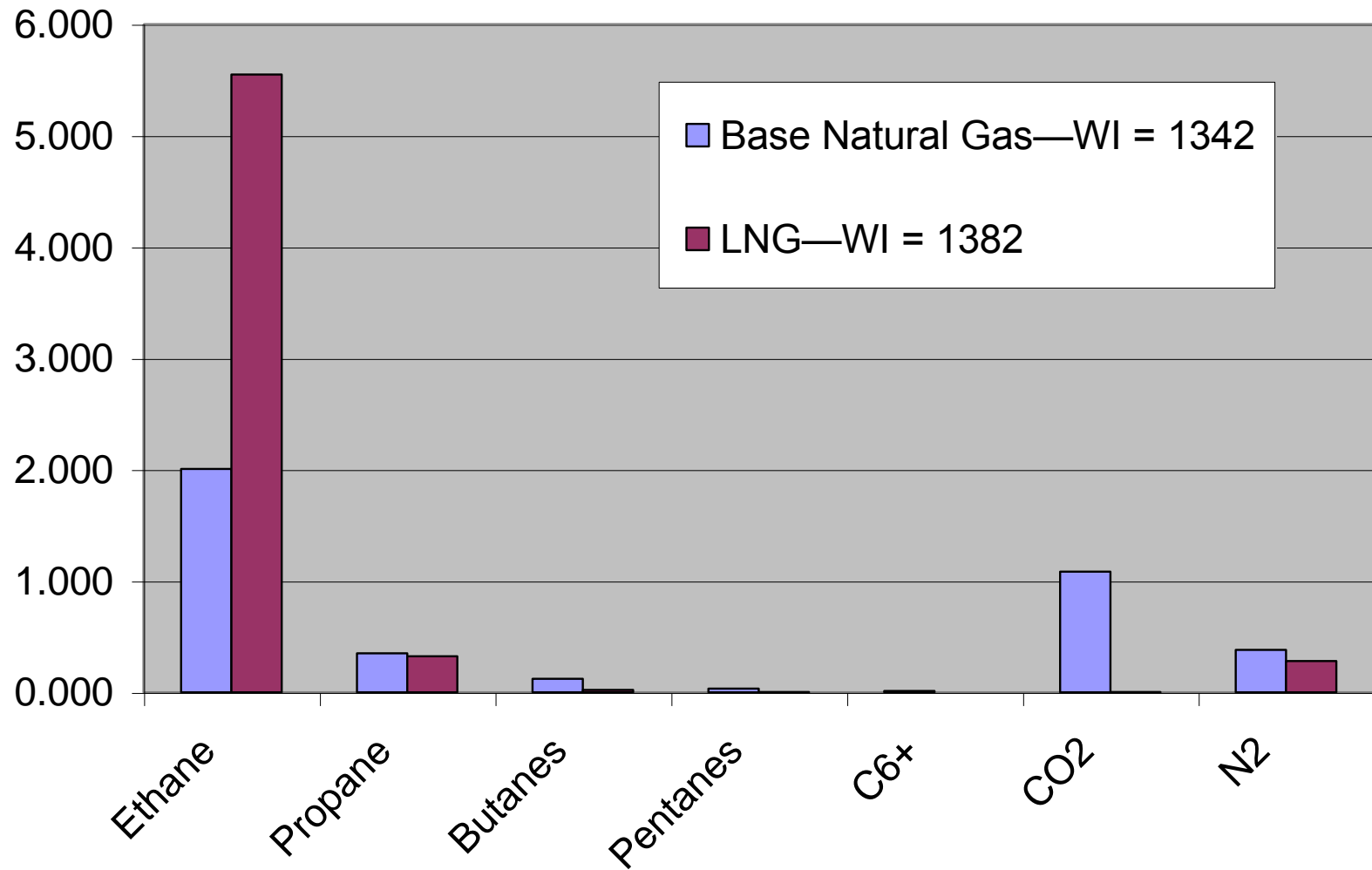
# Preparation and LNG Tracking

- *Sempra provided valuable information on event timing and LNG composition*
- *SDG&E and SoCal Gas provided valuable help in locating LNG impact*
  - 4 new GC monitors, made information available to the District in real time,
- *Portable GCs (District and SDG&E) to track LNG*

# ECA Start Up Geographic Monitoring



## LNG Event Natural Gas Composition



# DRAFT

# District Source Test Results

Description	Rated Load, MMBtu/hr	Emissions Change with LNG-Derived Natural Gas			
		NO <sub>x</sub>		CO	
		Baseline, ppmv	Change from Baseline, %	Baseline, ppmv	Change from Baseline, %
Boiler, LNB, FGR, O <sub>2</sub> Trim	72	25.3	1	18.5	56
Boiler, LNB, FGR, O <sub>2</sub> Trim	12.6	24.2	5	3.6	68
Boiler, LNB, FGR, O <sub>2</sub> Trim	23.8	26.6	2	108	0

DRAFT

# District Source Test Results

Description	Rated Load, BHP	Emissions Change with LNG-Derived Natural Gas			
		NO <sub>x</sub>		CO	
		Baseline, ppmv	Change from Baseline, %	Baseline, ppmv	Change from Baseline, %
Engine, Rich Burn, three-way catalyst	500	1.0	-11	737	3
Engine, Lean Burn	2400	45.1	-19	218	2
Engine, Lean Burn	2400	35.7	-16	210	0

DRAFT

# District Source Test Results

Description	Rated Load, BHP	Emissions Change with LNG-Derived Natural Gas			
		NMHC		VOCs	
		Baseline, ppmv	Change from Baseline, %	Baseline, ppmv	Change from Baseline, %
Engine, Rich Burn	500	10.2	53	2.5	-35
Engine, Lean Burn	2400	91.9	61	42.9	1

# DRAFT

# District Source Test Results

Description	Rated Load, MW	Emissions Change with LNG-Derived Natural Gas			
		NO <sub>x</sub>		CO	
		Baseline, ppmv	Change from Baseline, %	Baseline, ppmv	Change from Baseline, %
Gas Turbine, Water Injected	18.3	30.8	-6	N/A	N/A
Gas Turbine, DLN (LNG WI = 1371 avg)	5.2	11.5	1	0.7	0
Gas Turbine with Duct Burner, DLN, LNB	9.2	15.2	10	3.7	-33
Gas Turbine with Duct Burner, DLN, LNB (LNG WI = 1377 avg)	5.2	14.2	1	4.1	5

# SoCal Gas/SDG&E Results

Equipment Description	Heat Input, MMBtu/hr	Emissions Change with LNG-Derived Natural Gas			
		NO <sub>x</sub>		CO	
		Baseline, ppmv	Change from Baseline, %	Baseline, ppmv	Change from Baseline, %
Boiler (heat input was 7% less on LNG)	16.8	30.2	-4	14.9	-12
Boiler	4.6	90	9	337	-31
Boiler—low load	7.2	26	-4	54	-22
Boiler—high load	7.2	30	-3	14	-7
Boiler—likely malfunctioning oxygen trim system	27.8	31	3	6	2500
Boiler (different boilers for baseline and LNG tests)	25.1	20	5	1	-100

# SoCal Gas/SDG&E Results

Equipment Description	Heat Input, MMBtu/hr	Emissions Change with LNG-Derived Natural Gas			
		NO <sub>x</sub>		CO	
		Baseline, ppmv	Change from Baseline, %	Baseline, ppmv	Change from Baseline, %
Engine, Lean Burn— before manual adjustment (LNG WI = 1363–1372)	8.2	62	13	198	3
Engine, Lean Burn— after manual adjustment (LNG WI = 1363–1372)	8.2	62	3	198	3
Gas Turbine	17.0	61	5	91	-4

# SoCal Gas/SDG&E Results

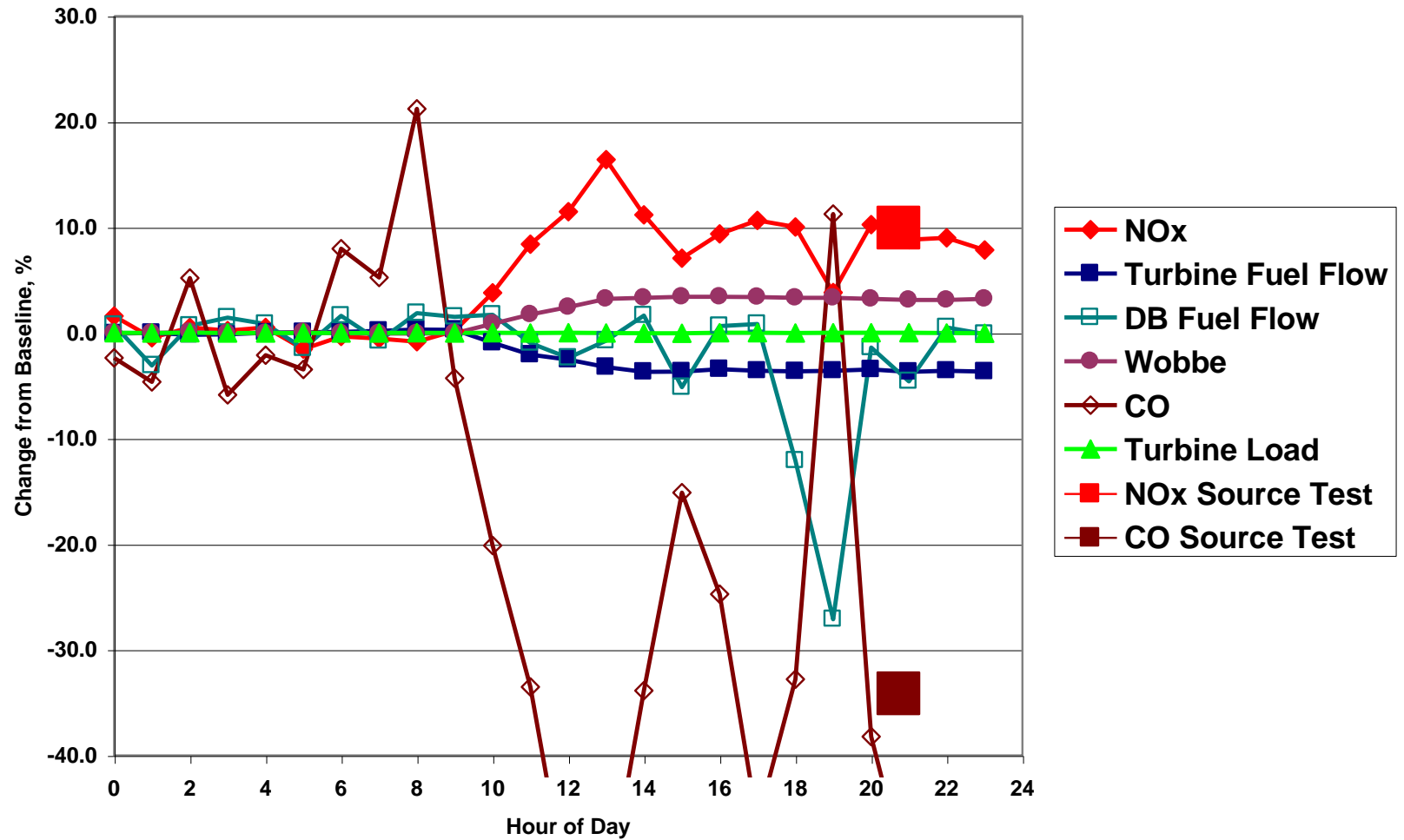
Equipment Description	Heat Input, MMBtu/hr	Emissions Change with LNG-Derived Natural Gas			
		NO <sub>x</sub>		CO	
		Baseline, ppmv	Change from Baseline, %	Baseline, ppmv	Change from Baseline, %
Kiln	0.374	63	-8	43	40
Pool Heater	4.0	171	7	0	N/A

# CEMS Data



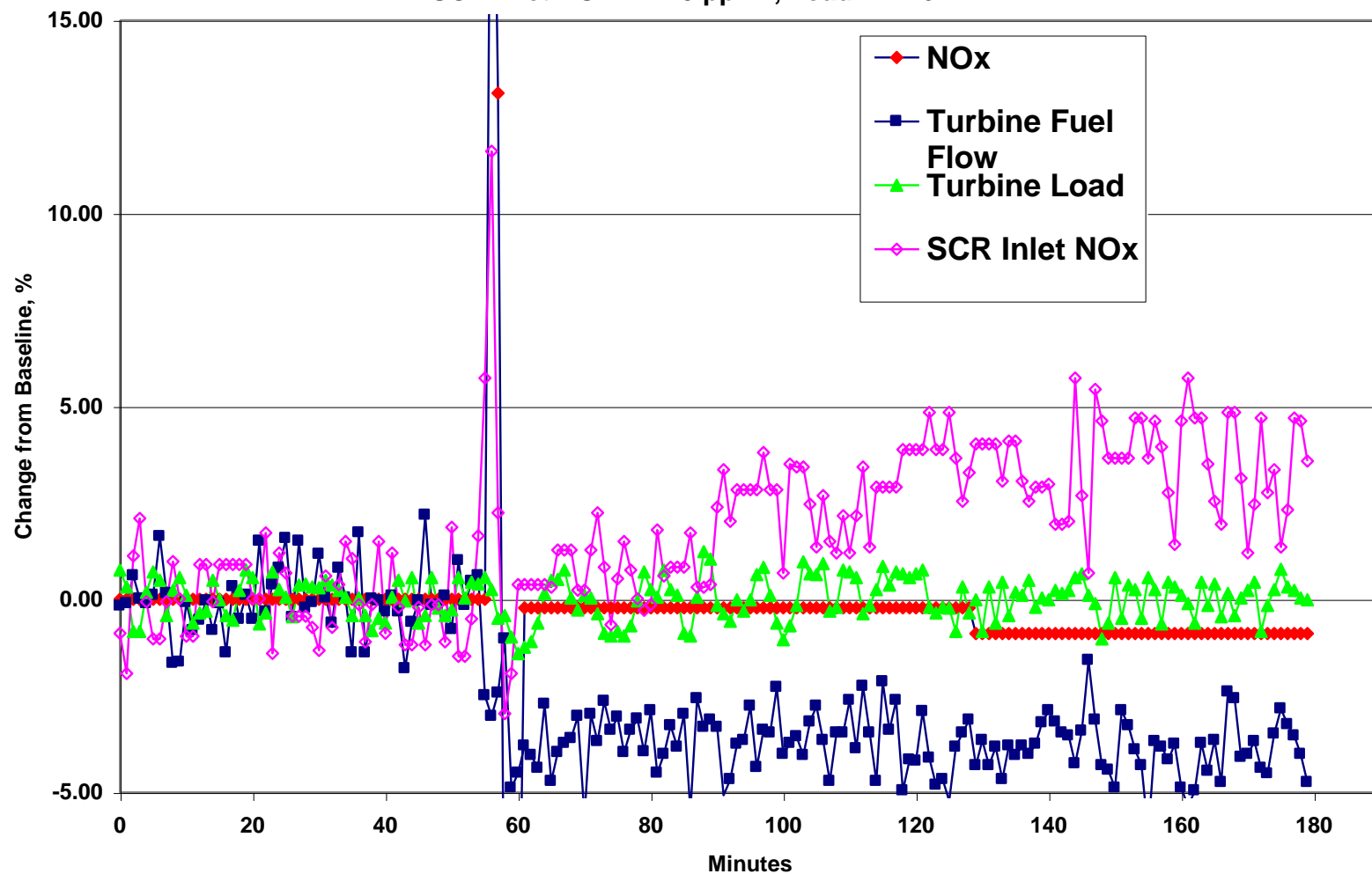
## LNG Event CEMS Data—Turbine, 9.2 MW, Duct Burner, 38 MMBtu/hr

Wobbe Index: 1336–1382, Baselines: NOx = 15.5 ppmv, CO = 2.1 ppm,  
Turbine Load = 8MW, Duct Burner Heat Input = 32.9 MMBtu/hr



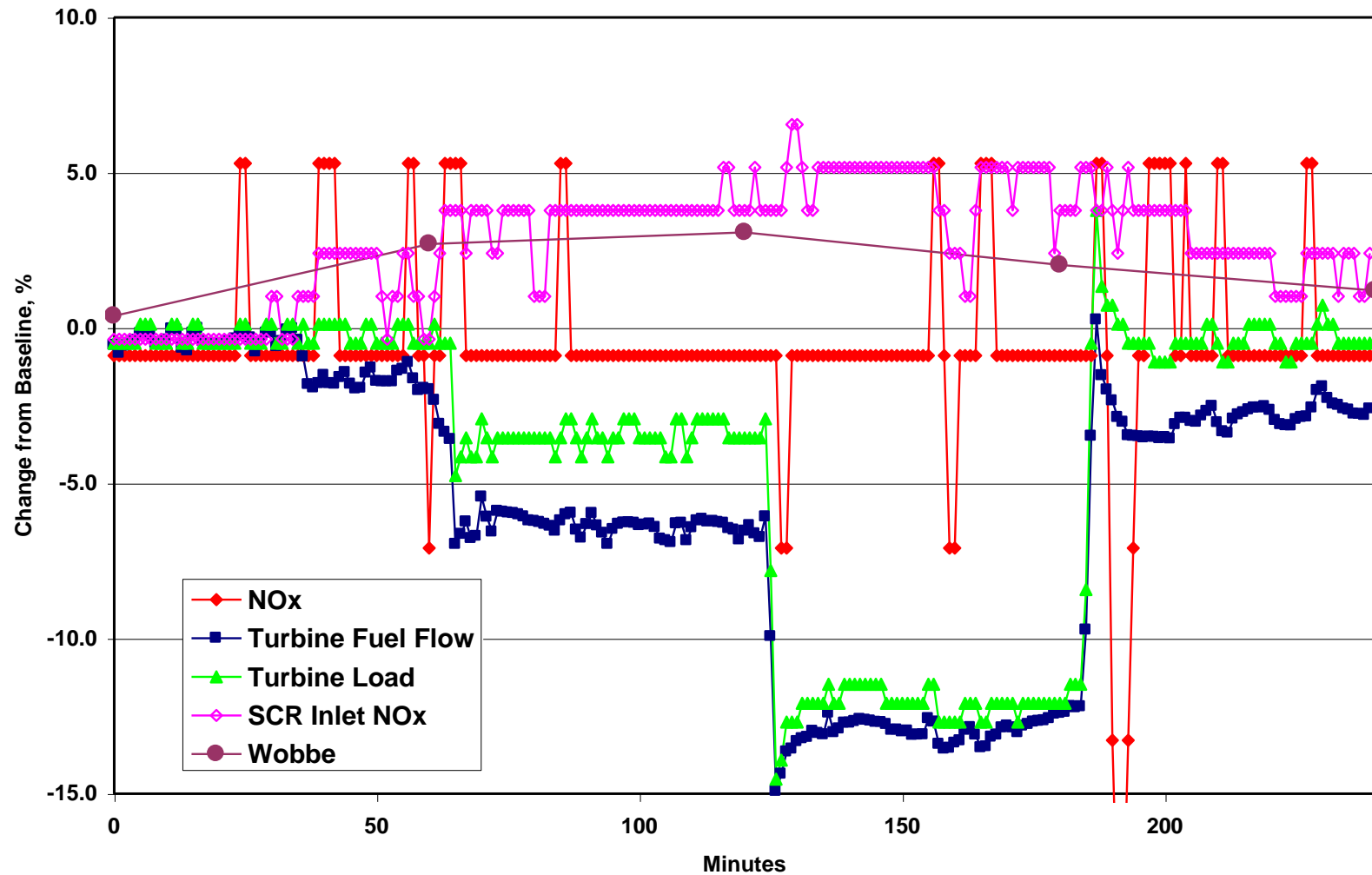
# LNG 5-9-08 Event CEMS Data—Turbine, WI, SCR, 42.4 MW

Wobbe Index: 1337–1383, Baselines: NO<sub>x</sub> = 4.5 ppmv,  
SCR Inlet NO<sub>x</sub> = 44.5 ppmv, Load = 41.6 MW



# LNG 5-9-08 Event CEMS Data—Combined Cycle Turbine, LNB, SCR, 170 MW

Wobbe Index: 1336–1377, Baselines: NOx = 1.6 ppmv, SCR Inlet NOx = 8.6 ppmv,  
Load = 163.8 MW



# Conclusions



# Emission Changes: NO<sub>x</sub> & CO

- *LNG not expected to cause emission increases greater than about 10% for NO<sub>x</sub> from the industrial equipment and gas composition tested*
- *CO changes are often larger*
- *Emissions may decrease in some cases*
- *Data supports no significant increases with active air pollution control devices*

# Emission Changes: VOCs

- *LNG not expected to cause emission increases greater than about 10% for VOCs from the industrial equipment and gas composition tested*
- *VOC emissions may decrease in some cases*
- *NMHC increase may indicate potentially larger VOC increases with different LNG composition*


# Compliance Issues

- *District source tests and CEMS data showed no compliance problems for equipment tested*
- *Even small increases may be an issue*
- *SoCal Gas/SDG&E testing showed two potential exceedances of NO<sub>x</sub> limits*
  - Lean burn engine—tuning resolved
  - Boiler—2 ppmv, but exceeded by 1 ppmv on base gas
  - District doesn't use portable analyzer for compliance

# Reliable Basis?

- *Limited scope*
- *Equipment tested self-selected*
- *Only one LNG gas composition tested  
(less C3 and C4 than base natural gas)*
- *Likely did not fully capture the potential  
emission increases from permitted  
equipment*

# Additional Issues

- *Inventory of combustion system types*
  - *Large number of smaller industrial, commercial, and residential natural gas combustion devices*
  - *Mobile sources*
  - *Natural gas distribution system fugitive emissions*
  - *Fluctuating gas quality*
- 
- Decorative concentric circles in the bottom right corner of the slide.

# Overall Conclusion

- *Emission increases from LNG derived natural gas are counterproductive for attainment of ambient air quality standards*
- *More research and information needed to fully assess potential impacts basin-wide*

# Acknowledgements—District Staff

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